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The Patent Offic
Cardiff Road
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1. Your reference MARINE/HYDRAULIC

2. Patent application number *(The Patent Office will fill in this part)* 0229042.7 | 13 DEC 2002

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

8083990002

Patents ADP number *(if you know it)*

Marine Current Turbines Limited,
The Manor House,
Chineham Court,
Lutyens Court,
Chineham,
Basingstoke,
Hampshire RG24 8AG

If the applicant is a corporate body, give the country/state of its incorporation

A British Company

4. Title of the invention Hydraulic Speed-Increasing Transmission for Water Current Powered Turbine

5. Name of your agent *(if you have one)*

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

Patrick Russell-Rayner
Business Centre West, Avenue One,
Business Park, Letchworth Garden City,
Hertfordshire SG6 2HB

Patents ADP number *(if you know it)*

7488984001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

a) any applicant named in part 3 is not an inventor, or

b) there is an inventor who is not named as an applicant, or

c) any named applicant is a corporate body.

See note (d))

Yes

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	NONE
Description	NINE
Claim(s)	NONE
Abstract	NONE
Drawing(s)	TWO

10. If you are also filing any of the following, state how many against each item.

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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	
Request for preliminary examination and search *(Patents Form 9/77)*	
Request for substantive examination *(Patents Form 10/77)*	
Any other documents *(please specify)*	

11. I/We request the grant of a patent on the basis of this application.

Signature P. Russell-Rayner Date 13/12/02

12. Name and daytime telephone number of person to contact in the United Kingdom Pat Russell-Rayner 01462 672538

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HYDRAULIC SPEED-INCREASING TRANSMISSION FOR WATER CURRENT POWERED TURBINE

BACKGROUND OF THE INVENTION

This invention relates to turbines and other such devices capable of interacting with a flow of fluid in such a manner as to transfer energy from the fluid to a mechanical device. This invention relates more particularly to turbines or other such devices arranged to be driven by the action of a flow of water or other liquid medium. Thus, the present invention relates in particular to the use of turbines and similar moving devices for extracting kinetic energy from flowing water for the purposes of utilising such kinetic energy to produce either electricity or shaft power for utilisation for a required purpose. Flowing water (which may be either fresh water or sea water) used in the context of this invention is a characteristic of tidal, marine, estuarial or river currents.

It is known how to use turbines for such purposes. For example, in our British Patents GB 2256011 B and GB 2311566 B and also in our British Patent Application No 2348250 we have disclosed constructions pertaining to water driveable turbines; i.e. rotors supported within the water column of the sea, river or an estuary so that the flow of water may turn the rotor to produce shaft power and hence possibly electricity for utilisation for a required purpose.

Various alternative concepts for achieving similar results have been proposed by others.

In particular the present invention relates to a power transmission system for use with one or more such turbine rotors for extracting kinetic energy from flowing

Figure 2 also shows the water motor or Pelton Turbine driving an electrical generator (12) by way of pulleys and a belt. This is primarily to clarify the principles being illustrated since in practice the generator may in fact be direct coupled to the Pelton Turbine or Water motor (i.e. the shaft of the generator directly engaged with the shaft of the water motor), but equally some speed changing transmission such as a belt or belts may be used. Since some of the water used as hydraulic fluid may leak from the circuit, especially from the high pressure pump or pumps (3 and 8), any losses will need to be made up to ensure a continuous feed supply to the pump or pumps. In practive it is desirable to allow some leakage since good clearances and less than perfect sealing will in all probability reduce the mechanical losses in the pump(s) and thereby improve the overall system efficiency;. This arrangement in practice could also very probably make it easier to obtain long intervals before any pump seals need replacement.

To accomodate any such leakage a a make-up water supply is provided in which a header tank (13) is mounted such that its water static level is immediately below the water motor or Pelton Turbine as illustrated, so that if the level in the return supply pipe (7) falls significantly below that in the header tank, some make up water will flow from the header tank through a non-return valve into the circuit near the top of the low pressure return supply pipe.

The header tank (13) is topped up when a level sensor (14) detects that the water level has fallen below some predetermined level; when this happens a small feed pump (15) is operated to draw water from the surroundings to the system through an intake with a strainer and filter system (16) and to pump it through a maekup water feed pipe (17) into the header tank. When the water level in the header tank exceeds a predetermined height, then the feed pump is switched off. In most cases said feed pump will be electrically energised.

may be used, and so could gear, vane, lobe or other types of low speed, high pressure positive- displacement pumps.

A circular plenum or ring main (4) feeds the pump with water through a non-return valve to each cylinder (the shape of this plenum or ring main may vary to suit other pump configurations and may not necessarily take the shape of a ring main and feed four cylinders- in some cases with a single entry point to a pump a single feed pipe will suffice.

Water expelled at high pressure from the pump cylinders goes via non-return valves into another high pressure plenum or ring main (5). Said high pressure outlet from the pump interconnects to an optional surge-chamber or accumulator (6) capable of absorbing pulses in the flow and smoothing the output which flows away through a high pressure main (7). Any other pumps (8) driven by other rotors also feed into the same high pressure main (7).

Similarly feed water to the pumps arrives at the feed plenum (4) via a low pressure supply line (9) which also feeds any other pumps(8) driven by other rotors.

The high pressure water main (7) transports the high pressure water emitted from the pumps to a water motor or Pelton Turbine (10). Said water motor or Pelton Turbine is prior art and simply offers an efficient and well known mechanism for obtaining a high speed output from a jet (or in some cases several jets) of water. In this case the high pressure water main terminates in one (or more) nozzles (11) which cause a high velocity jet (or jets) of water to impinge on the buckets or blades of the water motor or Pelton Turbine shown schematically as (10). In many cases a multi-jet Pelton Turbine may be used although the Figure for simplicity only shows the single jet option. The advantage of a multi-jet installation is that better part-load efficiency may be gained by using fewer jets when only a limited water supply is available.

also shows, ghosted, a key feature of our previously mentioned British Patent No 2311566 B in which the turbines and their supporting "wing" can be raised above the surface of the flowing water for maintenance or repairs. This is an embodiment considered advantageous and preferred by the Inventor but is not an essential element for applying this invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

Figure 2 is a schematic diagram showing an embodiment of a system incorporating the concepts of the present invention and in particular illustrates how the system shown therein could be applied to an installation such as that in shown in Figure 1 Although Figure 2 shows the invention schematically in the configuration of two rotors with two pumps, as might be applicable with the system shown in Figure 1, the features of the system shown therein can be applied to other types of water current turbine with any number of rotors from a single one upwards.

In particular Figure 2 shows a hydraulic system with the following features:-
A rotor (1) (part shown in profile by broken lines) drives a shaft with a cam drive (2) comprising in this example of an offset circular profile. In this system an example is given of a four cylinder pump driven by the cam drive. The cylinders (3) are in this example symmetrically disposed around the cam with their centre-lines or axes in the plane of the cam.

Pistons or plungers are driven radially by the cam through roller type cam followers and they may have a spring return (not illustrated) inside each cylinder. This pump concept is used purely by way of example. For the practicing of the present invention the form of pump used can be of any form suitable for the intended purpose for example, other piston or plunger type pump configurations

Therefore the makeup water is drawn through a strainer and then a filter by an ancillary pump and fed into a a header tank or storage tank; said pump only functions at times when a float or other level indicating transducer signals that the water level in the storage tank has fallen below some predetermined level and it ceases to function when the tank is replenished to another higher predetermined level. The aforementioned storage or header tank is linked to the water return feed pipe which collects water from below the Pelton Turbine or water motor and returns it to the feed manifold of the low speed, high-pressure pump (or pumps).

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention and to show how to carry the same into effect reference will now be made to the accompanying drawings in which:-

Figure 1 is a schematic view of an example of a known proposal for a water current turbine system, and which illustrates the context in which this invention will be applied.

Figure 1A is a section on the line A-A of Figure 1,

Figure 1B is a section on the line B-B of Figure 1; and

Figure 2 is a schematic diagram showing the invention and how it might be applied to an installation such as that in Figure 1.

DESCRIPTION OF A KNOWN EMBODIMENT

Referring to Figure 1 the turbine system shown therein incorporates twin rotors mounted either side of a mono-pile support structure. Each rotor drives a generator through no specific type of speed increasing transmission. The figure

necessary when rotary positive displacement pumps such as gear pumps are used, as their output tends to be relatively smooth and free from pressure pulses).

The low pressure and the high pressure transmission pipes will be led through the support structure of the tidal turbine to a convenient location for placing a water motor or Pelton Turbine connected to a generator. The water motor or Pelton turbine will generally be driven by one or more jets of water impinging on a specially shaped runner; such devices are prior art and well known.

In the application of this invention to the tidal turbine concept we have previously described in our British Patent GB 2311566 B and also in our British Patent Application 2348250, the turbines are mounted on a mono-piled support structure that is installed in a socket drilled into the seabed or river bed and the upper end of said support mono-pile emerges above the surface of the flowing water current. When this invention is applied to this method for extracting kinetic energy from currents then the low pressure and the high pressure transmission pipes will carry the flow to and from a water motor or Pelton Turbine driving a generator that is preferably located above the surface of the water in a weather proof housing on the top of the supporting mono-pile. However the housing for the water motor or Pelton Turbine may in some cases be a water tight casing located under the surface in the case of systems that do not penetrate the surface.

An important element of this invention is that the water used in the system needs to be filtered so as to be free of significant quantities of suspended solids or debris which would otherwise prematurely wear the components of both the pumps and the water motor or Pelton Turbine.

The water may also be dosed with a non-harmful (bio-degradable or bio-friendly) lubricant to help minimise wear and tear of seals and moving components in the system.

In particular the hydraulic pump may be of various types, such as, for example, a cam or crank driven single or multi-cylinder piston or plunger type of pump, or an internal or external type gear pump, a lobe pump or a vane pump.

Conveniently, pumps utilised may be presented in a variety of configurations, such that, for example, a piston or plunger pump may have a multiplicity of cylinders disposed radially around the cam or driving crank on the main shaft, or the cylinders may be disposed axially along a camshaft or crankshaft, or there may be a series of radially disposed cylinders set axially along a camshaft or crankshaft.

The concepts of the invention may be applied to water current turbines with more than one rotor, in which case each rotor will be coupled to a similar low speed, positive displacement pump fed with the same working fluid that the turbine runs in, whereby if the pump is in the sea it will be sea water, if in an inland river it may be freshwater. Therefore any minor leakage of hydraulic fluid will not create any environmental problem of polluting the surroundings and is acceptable.

The individual cylinders (with piston or plunger pumps) or the pump output will draw in water via non-return valves from a low pressure or supply manifold and similarly they will deliver the high pressure pumped water through a non-return valve into a high pressure manifold.

The low pressure manifold will be connected to a low pressure supply pipe or feed pipe which will carry an adequate supply of working fluid to meet the needs of the pump(s). Similarly, the high pressure manifold will in turn be connected to a high pressure supply or transmission pipe and it may also interface with an accumulator capable of absorbing fluctuations or pulses in the output caused by the use of piston or plunger pumps (the use of an accumulator may not be

handle, costly, suffer significant wear and require regular maintenance to replace the lubricant. Gearboxes also introduce a hazard to the local environment should the lubricating oil leak out for any reason.

THE PRIOR ART

The concept of immersing a rotor in a water current in order to extract energy has been tested and described, as for example in our British Patents and Patent Applications cited earlier. The concept of using a hydraulic pump to drive a faster moving hydraulic motor as a method for increasing the speed of the output from a prime mover is also well known and the components necessary are even widely available as industrial products. The use of water as a hydraulic fluid is also known.

STATEMENTS OF THE INVENTION

Broadly according to a first aspect of the present invention a water drivable turbine is provided with a hydraulic power transmission system for increasing the effective speed of the turbine.

Preferably the hydraulic medium used by the system is the same medium as that in which the turbine is operationally immersed.

Thus a primary aspect of the invention provides a power transmission system based on hydraulic power transmission using water as a working fluid in order to achieve the desired increment in speed to couple a low speed tidal or river current turbine rotor to a conventional electrical generator or to other high speed machinery.

In a preferred arrangement it is proposed to directly couple a low speed, positive displacement hydraulic pump to the turbine rotor drive shaft.

water and producing therefrom electricity by driving an electrical generator or alternator or for applying the power for some other useful purpose requiring a fast rotating shaft. The concept to be described is a generic concept that is applicable to any kind of device that can produce shaft power from moving currents and not necessarily the devices described in the aforementioned patents and patent applications.

Generally a turbine for extracting kinetic energy from water currents, whether in a river or at sea, consists of a rotor capable of interacting with the flow of water in such a way that some of the energy of motion of the passing mass of water causes the rotor to rotate. No matter what kind of rotor is used, whether an axial flow or propeller type of rotor or a cross-flow rotor of the so-called Darrieus type, or even some other form of hydrofoil device reacting against the flow of water currents, the rotation of a rotor driven by the movement of water currents will be slow due to the fact that even the fastest of water currents only run at relatively slow speeds in the range from 2 to 4m/s at most and the rotor extremities cannot generally move much faster than 10 to 15m/s. Consequently only small devices can rotate at reasonably high speeds since the larger the device, generally the smaller the angular movement in a given time.

Therefore it becomes necessary to provide some means for speeding up the output gained from the rotation of a slow moving rotor in order to effectively drive an electrical generator or other relatively high speed machinery. For example an axial flow tidal or river current turbine rotor 15m in diameter will typically rotate at about 10 revolutions per minute in a driving current of 2 to 2.5m/s (4 to 5 knots) but most conventional electricity generators typically require to be driven at shaft speeds of 1000, 1500 or more revolutions per minute. There is therefore a need to increase the speed of the main turbine shaft by a factor of 100 or more. The most generally proposed technique, which is prior art, is by using a multistage gearbox. However gearboxes of such a kind are complicated mechanically, heavy to

1/2

PRIOR ART

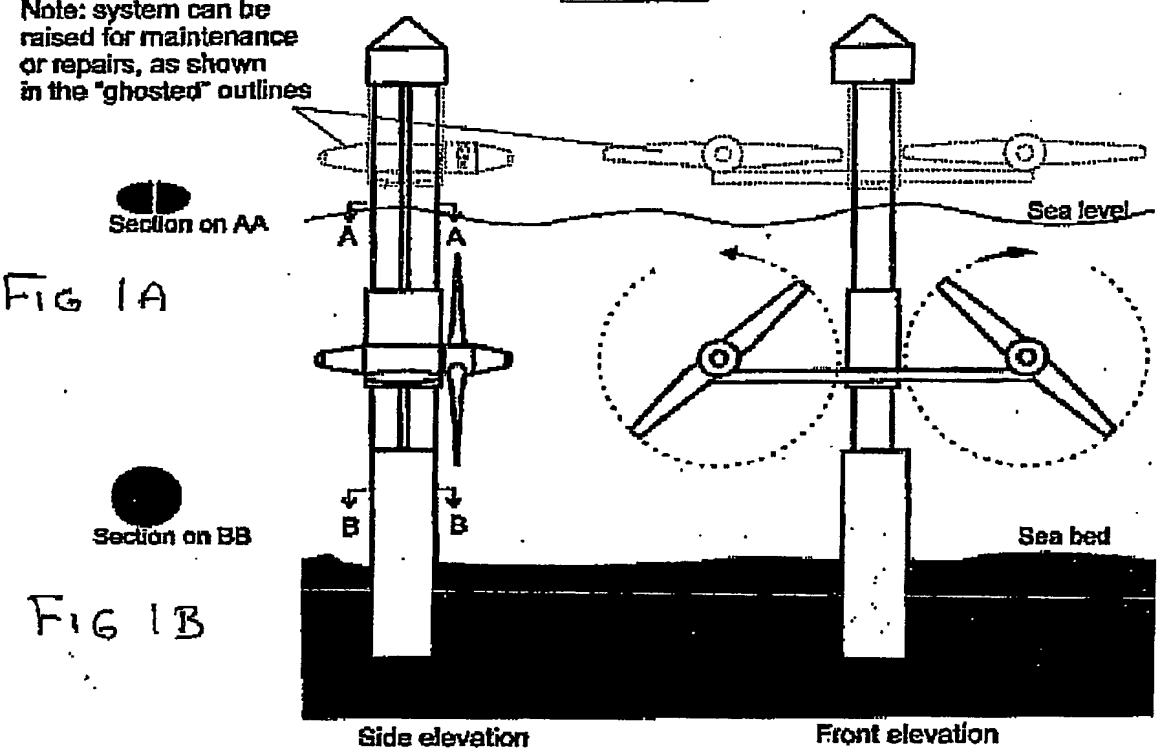

FIG 1A

FIG 1B

Figure 1

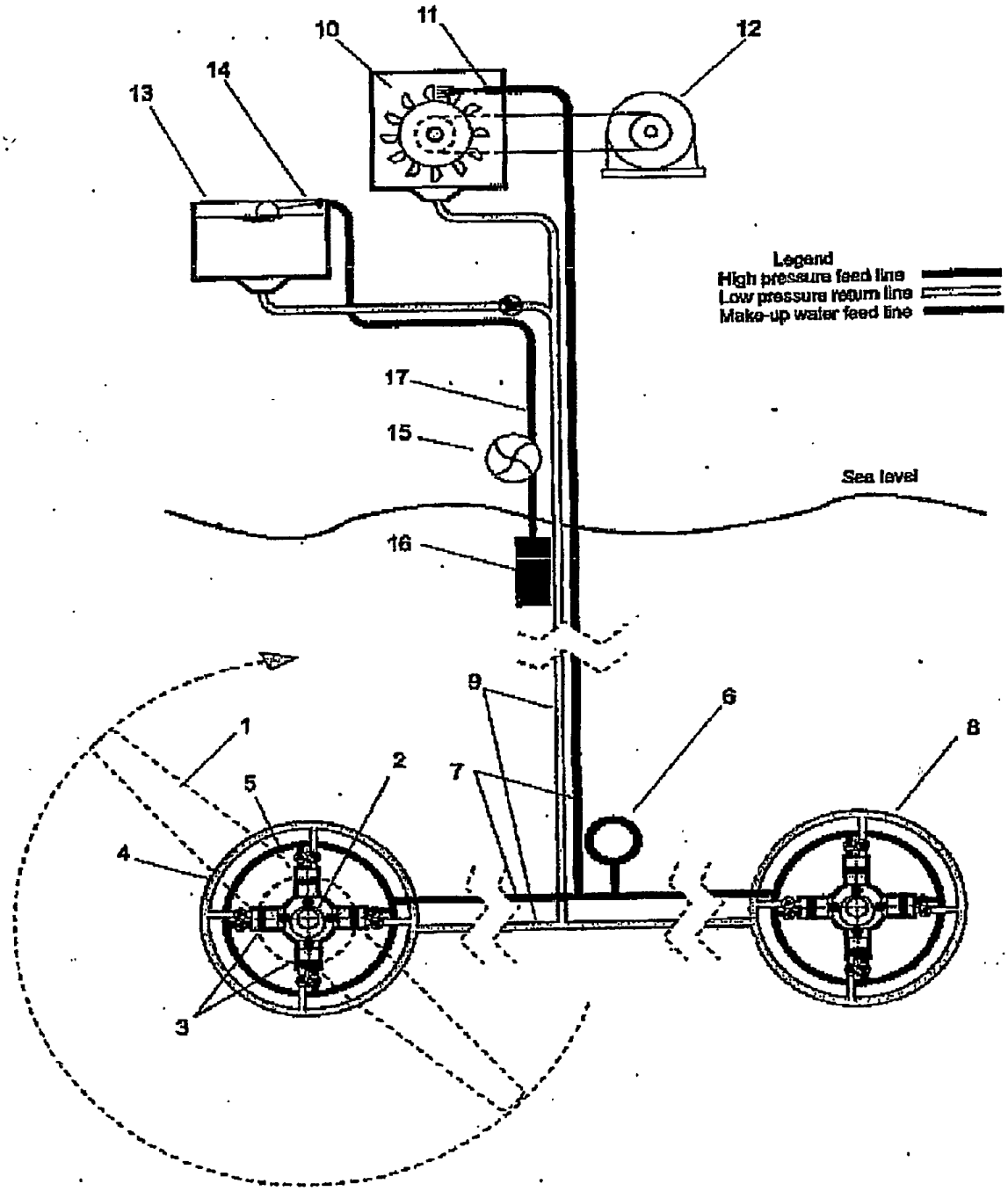

Figure 2

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